| Waves | **Total internal reflection** |
|---|---|

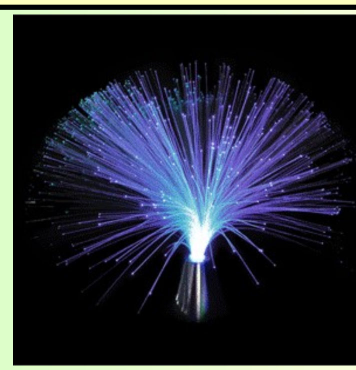
| | | |
|---|---|---|
| **Learning objectives** | **MUST (6)** | Recall definitions of total internal reflection and critical angle, and derive the equation for critical angle |
| | **SHOULD (7)** | Explain the structure and purpose of optical fibres |
| | **COULD (8/9)** | Apply the equations to multi-step problems |

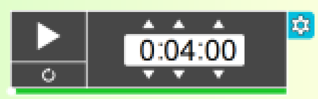
**STARTER:** Austin Powers has kindly lent us this lovely 1970s lamp.

Groovy!

But hang on - we've always been told that light travels in straight lines. Why does the light still travel along the fibres, even when we bend them?

**EXTENSION:** What, if anything, would change about the light when it entered the fibre?



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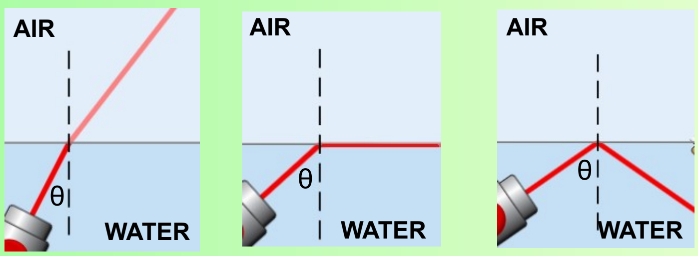
| Waves | **Critical angle and optical fibres** |
| --- | --- |
| **MUST (6)** | Recall definitions of total internal reflection and critical angle ,and derive the equation for critical angle |

When a wave is passing from a **higher** to **lower** refractive index - such as from water to air - it is possible for **total internal reflection** to occur. This is when all of the wave is reflected from the surface, and none passes through.

TIR occurs if angle of incidence is greater than a 'critical angle', C.




$\theta < C$ $\theta = C$ $\theta > C$

[redacted]

Remember Snell's Law for refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ ($n_1$ is the denser medium here)

What's the angle of refraction at the critical angle?

The angle of refraction is 90°, so at the critical angle C Snell's law becomes:

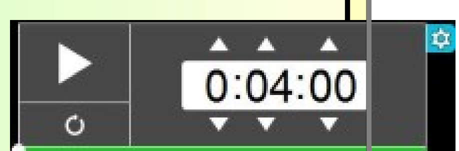
$n_1 \sin C = n_2 \sin 90°$

Because sin 90 = 1, we can say: $n_1 \sin\theta c = n_2$

Can rearrange: $\sin C = n_2/n_1$, and $C = \sin^{-1}(n_2/n_1)$

The refractive index for air is 1, so if the light is going from a substance with refractive index *n* to air:

$$\sin C = \frac{1}{n}$$

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| | |
|---|---|
| Waves | **Critical angle and optical fibres** |
| **SHOULD (7)** | Explain the structure and purpose of optical fibres |

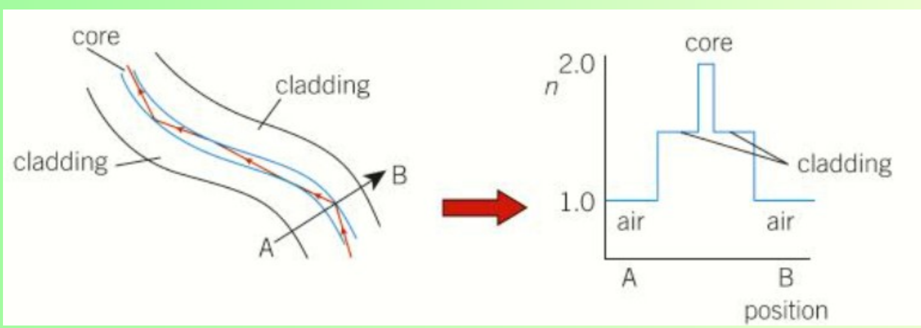
Optical fibres totally internally reflect pulses of light that travel down them.

Uses include:

Information transfer. Advantages over copper wire: can carry much more data, and has very little signal loss.

Endoscopy (allowing doctors to see clearly inside the patient - carrying light into the patient's body and relaying images back).

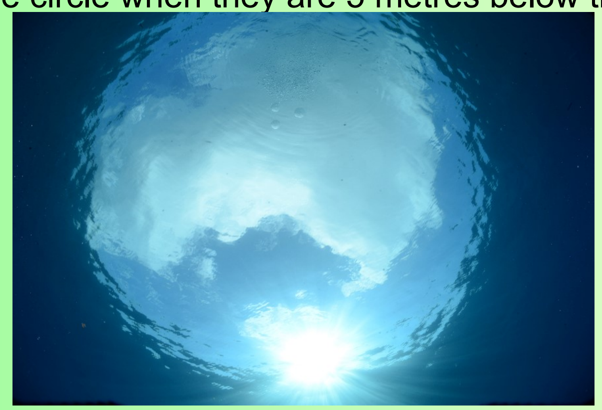
Structure: core (high refractive index) and cladding (lower refractive index)



| Waves | **Critical angle and optical fibres** |
|---|---|
| **COULD (8/9)** | Apply the equations to multi-step problems |

Try the PPQ, showing your working at every stage.

Extension: When an underwater diver in deep sea looks up towards the water's surface, their view shows mostly darkness with a circle of light. Can you work out why? Given that the refractive index of seawater is 1.339, can you work out the radius of the circle when they are 5 metres below the surface? (This is tricky. Ask for a hint).



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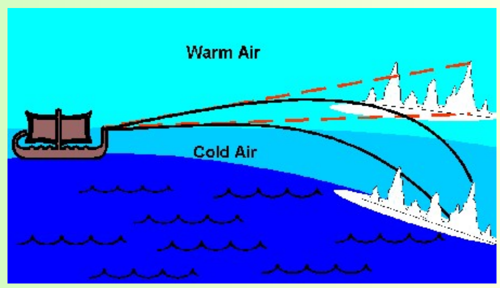
| Waves | Total internal reflection | |
|---|---|---|
| Learning objectives | MUST (6) | Recall definitions of total internal reflection and critical angle |
| | SHOULD (7) | Explain the structure and purpose of optical fibres |
| | COULD (8/9) | Apply the equations to multi-step problems |

**PLENARY:** Greenland was probably discovered because of total internal reflection; the Vikings knew that an island was there, even though they couldn't have actually seen it directly, and sailed towards it. Look at the diagram - can you suggest how? Clue - think about cold air and hot air. What properties would you think differ?




**EXTENSION:** Would you expect this effect to remain as they sailed closer towards it? Explain.

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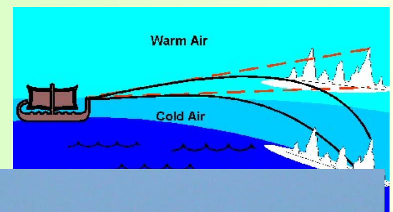
| Waves | **Critical angle and optical fibres** |
|---|---|

| | | |
|---|---|---|
| **Learning objectives** | **MUST (6)** | Find the critical angle of a material (and possibly derive the equation) |
| | **SHOULD (7)** | Explain the structure and purpose of optical fibres |
| | **COULD (8/9)** | Apply the equations to multi-step problems |

**STARTER:** We started the lesson with a picture of a 'superior mirage'.




Here is a picture of a different kind of mirage that you might be familiar with; a shimmering on tarmac on a very hot day. Can you explain?

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